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A Sectorial Analysis of the Green Maritime Energy Industry in Scotland: Strategies and Frameworks for Development and Growth

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ABSTRACT

The Scottish Government is committed to a policy aim of ensuring that Scotland's energy needs be met solely by renewable energy sources by 2020. This has encouraged stakeholders to invest resources to speed the development and growth of the renewable energy sector. The offshore wind, wave and tidal sectors that comprise the green maritime energy industry has been the locus of much innovation, investment and channelling of resources to exploit the advantages of Scotland's geographical advantage for wind and wave resources. This article reports on findings from a sectorial analysis of green maritime energy industry in Scotland conducted for the EU funded Harvest Atlantic project. Attention has been focused on key activities that combine to help drive growth in the sector and includes identification of the supply chain activities; analysis of the regulatory and strategic framework within which companies in the supply chain operate; findings and discussion of questionnaire surveys featuring innovation and human capital across the industry; analysis of the market situation facing the industry; and the key policy implications. Whilst significant progress has been made, the aim of achieving the Scottish government's stated strategic aim for the sector has been slowed by rising costs, skills gaps and economic uncertainty. Also, it is evident that regulatory frameworks can act to hinder rather than support progress in the development of the green maritime energy industry.

1. Introduction

The Scottish Government is committed to a policy aim of ensuring that Scotland's energy needs be met solely by renewable energy sources by 2020 (OWIG, 2013). This commitment has encouraged stakeholders to invest resources to ensure that the development and growth of the renewable energy sector is on-track to achieve this aim. In particular, the offshore wind, wave and tidal sector of the green maritime energy industry has been the locus of much innovation, investment and channelling of resources to exploit the advantages of Scotland's geographical location in the north-west sector of Europe facing the vast Atlantic Ocean to the west and the North Sea to the east.

The green maritime energy sector consists of offshore wind, wave and tidal devices that generate electricity for the National Grid in the United Kingdom. The location of the devices, such as wind turbines and floating wave buoys, is governed by the Crown Office that allocate sections of the seabed for the purposes of investment and entrepreneurial activity by companies. A 2012 report by the Crown Estate noted that Scottish waters had the best potential for harnessing wave and tidal energy in the UK. Firms from around the world can apply to operate within the designated zones. The offshore wind energy sector is the most advanced, with standardised wind turbines producing just over 60% of all offshore capacity from Scottish waters. The wave and tidal sector remains in the developmental phase with several different designs and technologies undergoing experimentation and testing. However, some devices have become operational and contribute to the National Grid.

This article reports on findings from a sectorial analysis of green maritime energy industry in Scotland conducted for the EU funded Harvest Atlantic project with the objective of identifying and exchanging good practices and sustainable solutions

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based on innovation, diversification and marketing for the maritime economy to improve the socioeconomic situation of the Atlantic seaside territories, through transnational and interregional cooperation. Attention has been focused on key activities that combine to help drive growth in the sector and includes identification of the supply chain activities; analysis of the regulatory and strategic framework within which companies in the supply chain operate; findings and discussion of questionnaire surveys featuring innovation and human capital across the industry; analysis of the market situation facing the industry; and the key policy implications.

2. Methods

The main source of information for analysis is the secondary data provided by a wide range of industry support organisations including the Scottish government, Scottish Enterprise, Aberdeen Renewables, Offshore Wind Industry Group (OWIG), the European Wind Energy Association (EWEA) and others. Sources include industry reports, policy documents, regulatory framework documents, industry statistics, consultancy reports and academic articles. The second source of data for the study is based in primary data, qualitative information collected through semi-structured interviews with selected key players in the sector including industry support body Scottish Renewables, technology and innovation specialists ORE Catapult and the testing facility operators EMEC. Semi-structured interviews were carried out to gather information about the development and growth of the green maritime energy industry, support mechanisms, policy and regulatory frameworks, innovation and human capital deployment along the supply chain. Information and data from the semi-structured interviews from industry support bodies was supplemented by a survey questionnaire distributed to selected individual companies along the supply chain. The results form the basis of analysis for understanding the role of innovation in the industry's development and the skills, resource capacity and support for the deployment of human capital in the green maritime energy sector in Scotland.

3. Developmental Support For Green Maritime Energy in Scotland

The Scottish Government, alongside support agencies such as Scottish Renewables and Scottish Enterprise, have been instrumental in devising policies and strategies to effect substantial growth trajectories for the green maritime energy sector in Scotland. This includes reaching full offshore wind capacity and securing one third of the UK offshore wind market by 2020. According to IPA Economics (2010) this would secure an estimated gross value added in Scotland of £577.1bn and create 28,377 jobs. Since 2010, the green maritime energy sector in Scotland (wind/wave and tidal) has experienced significant investment and growth. In 2012 the number of offshore wind projects off the coast of Scotland increased by over 40% with applications constituting some 4GW of installed capacity in the UK. The sector has attracted international investment from companies such as E.ON, Samsung and Gamesa, making Scotland one of the global development leaders in the sector. Part of the attraction for international companies is the strategic leadership and continuing support of the Scottish Government, Scottish Enterprise, Highlands & Islands Enterprise, Scottish Development International and Scottish Renewables. These organisations have been able to access expert support that transfers knowledge to leading global companies with the aim of further encouraging innovation, investment and expansion into the Scottish green maritime energy supply chain.

Initiatives established include the Prototype Offshore Wind Energy Renewables Scotland fund (POWERS) which provides financial support for the capital and operational costs associated with the speculative production of full-scale prototypes of next generation offshore wind turbines (Scottish Government, 2013). The offshore wind expert support programme has also been developed to help companies that have not traditionally been involved with offshore renewables to consider and design diversification strategies for winning business in the sector. The programme has already worked closely with 70 separate companies and aims to work with a further 600 between 2010 and 2020.

Innovation is one of the key drivers of growth in the sector. However, there exist significant challenges in driving down costs, especially in the more advanced offshore wind sector. The long-term viability of the sector relies on the economics of development and returns on investment that encourages a further cycle of investment. The main support agencies outlined above alongside others such as the Scottish Funding Council has initiated strategies for innovation and monitor the outcomes closely. Models of best practice have been developed to ensure that feasible targets are set, outcomes measured and recommendations flow from the analysis of the industry data. Simultaneously, there are considerable efforts made by support agencies to promote collaboration and knowledge flows across stakeholder groups including developers, universities, research institutions, and support agencies. It is important that funding is channelled to areas of research and development that has impact and this is reflected in the establishment of support mechanisms such as the Wave and Tidal Energy Support Scheme (WATERS) and the Prototype Offshore Wind Energy Renewables Scotland Fund (POWERS). The latter is designed to help mitigate the financial risks associated with producing prototypes by providing funds for capital and operational costs incurred in the development of the next generation of offshore wind turbines.

Prioritisation of research and development and innovation along with industry engagement has led to Scottish Enterprise identifying a number of areas that can deliver significant cost savings to the industry in the near-term. For example, the Offshore Renewable Energy Catapult is a £5750m centre designed to accelerate the development of solutions to offshore engineering problems. In addition to the activities carried out by the enterprise agencies to meet the original recommendations, the offshore wind industry has undertaken several projects to promote ongoing technological innovation. In addition to the Cost Reduction Taskforce work, Mitsubishi Power Systems Europe Ltd (MPSE) plans to invest up to £57100 million in Centre for

Advanced Technology to carry out R&D into offshore wind turbine technology. This project brings together Technip Offshore Wind, Wood Group Renewables, and SSE at an early stage of development to work together investigating engineering interfaces. The project is expected to create 30 engineering jobs.

Finally, to ensure that Scotland exploits this opportunity, the Offshore Wind Industry Group (OWIG) was established in 2009, and produced Scotland's Offshore Wind Route Map. The group initially was co-chaired by the Scottish Government and ScottishPower Renewables, however, after being re-convened late in 2012 to update the route map, it is now co-chaired by Scottish Government and EDP Renewables. OWIG brings together:

- all offshore wind developers currently active in Scotland
- grid companies
- manufacturing firms
- academia
- relevant parties and key public sector bodies.

OWIG set out to determine what must happen to secure the large scale development of offshore wind in Scotland for decades to come. The route map was the culmination of the work undertaken to date and set out the key components and recommendations that would secure the maximum social, economic and environmental benefits available. These components comprise of:

- physical infrastructure
- supply chain development
- innovation
- grid capacity
- funding
- inward investment
- planning consents
- skills

4. Supply Chain of the Green Maritime Energy Sector

The supply chain in the green maritime energy sector consists of five key areas. Firstly consultants and developers work on the preparation, research and feasibility of projects. Specialist engineers, technicians and scientists test the devices and other technologies to ascertain their viability, safety and capabilities before project managers see the initiative through the phases of implementation, installation and decommissioning. Installation involves the physical deployment of devices in location. On-going maintenance forms the final part of the supply chain. Figure 1 illustrates the components of the green maritime energy supply chain.

Figure 1: Supply chain in the green maritime energy sector

Source: Authors

Consultancy and development services

A significant amount of developmental work has to be carried out before green maritime energy projects can be physically installed in location. This has created a whole new industry around specialist consultancy and development services including modelling; mapping; environmental impact assessment; sea floor environmental assessment; economic assessment and evaluation; marine safety and supply consultancy; specialists in permitting planning approvals, marine corrosion; engineering consultants; marketing and public relations consultants. In many instances the findings from research, consultancy and developmental services determines the viability of a project and helps to inform investment in the sector.

Testing

Testing covers a wide range of activities which are coordinated and integrated to provide valuable insights into the performance of new designs and innovations in the offshore green energy sector. These activities may include test facilities management; test operations and engineering; health and safety management; monitoring and evaluation; site preparation services; planning; demonstrations; subsea preparation; and reporting. The primary testing facility for offshore devices in Scotland is the European Marine Energy Centre (EMEC). The facility was established in 2003 as a centre of excellence in the testing of wave and tidal energy devices and technologies that efficiently and safely convert energy into electricity. EMEC test purpose-built technologies that generate electricity by harnessing the power of waves and tidal streams using purpose-built, accredited open-sea testing facilities in Orkney. There is ongoing investment in testing facilities in Scotland such as the new £572 million (part funded by the ERDF) purpose-built Marine Renewables Test Centre was opened at Dundee University in 2013. In a further development, SSE Renewables has received consent for an offshore wind turbine test facility at Hunterston from North Ayrshire Council in Scotland. There are also testing facilities for electrical engineering, tidal movements and stress analysis at universities such as Strathclyde, Glasgow and Edinburgh

Project management

After developmental work has been carried out, a more detailed analysis and testing phase takes place as projects progress through to the implementation, installation, maintenance and decommissioning stages. Project managers are also involved in the construction and manufacturing stage too. It is the role of project managers ensure that the preparation work for implementation is thoroughly planned and set out, that installation is planned and executed efficiently and safely, that maintenance takes place on an on-going basis, and decommissioning is undertaken to the highest environmental and safety standards. Project management may include site feasibility assessment; resource assessment and constraint analysis; environmental studies; consenting activities (such as consultations with stakeholders); planning activities related to construction and deployment, operations, maintenance and decommissioning.

Construction, manufacturing and technical development

The green maritime energy sector necessarily involves heavy equipment and plant. Wind turbines weigh several hundred tonnes and can reach heights of 60 metres. Construction, manufacturing and technical development can feature large-scale heavy equipment to small, hi-tech instrumentation, to winches and cables. Typical outputs include marine energy conversion device innovators, designers and developers; safety management; work platforms; underwater operators; cabling and electrical interconnections for marine operations/facilities; anchoring systems; engineering firms (electrical, civil, mechanical); on-site supervision and management; fabrication and final assembly. The green maritime energy sector has created jobs for many of the constructors with experience in the oil and gas industry as well as spawning a number of start-ups specialising in customised devices and equipment for the sector.

Installation

Installation includes a wide range of hardware covering transportation, offshore site preparation, device positioning and connection. Typical equipment includes wave/tidal/wind resource measuring devices; environmental monitoring devices; buoys; remote operating vehicle operators or owners; technical resource monitoring; data collection; winch, cable and mobile sea dock operators, civil engineering; surveyors. Although Scotland has a relatively strong track record in the offshore contracting industry based on oil and gas industries, the transfer of the added value skills, experience and resources to the green maritime energy sector has been problematic. This is mostly due to the differences in economic development in the sectors and the inability of the green maritime sector to attract key skills and resources in installation. Also, the conditions under which the green maritime energy sector operates is significantly different from the oil and gas industry. Offshore wind farms can only be established in areas designated by the Crown Office and are invariably located close to shore. Tidal and wave conditions vary according to location. For example, the proposed Tiree Array in the Atlantic area off the coast of the Outer Hebrides was abandoned partly because of the technical difficulties in installing equipment in challenging conditions. In response, and through research and industry engagement, Scottish Enterprise has developed actions that are based on learning from the oil and gas industry that can be transferred. However, these have focussed primarily on areas such as health and safety.

Operations and Maintenance

Following on from the construction, testing and installation of equipment is the actual operational use of it in very challenging environments. New skills and expertise are required in some operational and maintenance areas, such as tidal devices whereas in others well established techniques can be deployed, such as in cabling, port management, diving etc. The high standards of environmental protection needed has ensured that specific techniques have had to be developed to install and maintain many of the turbines and tidal and wave devices. This accounts for the elongated timeframe for experimentation in the sector. Typical operations and maintenance activities include operational monitoring; transportation; port facilities; marine operators with related experience (certified divers, vessel operators) of deployment, repair, and removal capabilities.

5. Regulatory Framework

The green maritime sector has a regulatory framework that has its origins in the European Commission but is enacted according to particular circumstances by Member States. Both the legal and regulatory frameworks have an important influence on the development and sustainability of green maritime energy sectors, and in particular, the level of on-going investment in the industry. Each Member State of the EU is responsible for introducing legislative measures into their own legal framework and these must include arrangements for licensing and consent for projects. In the UK, the Crown Office oversees applications for these in their role of executive management of the seabed in UK waters. Lindsay Leask of Scottish Renewables notes that the existing regulatory framework can act as a limiting factor - *"There will always be technical challenges of working in harsh environments such as in the case of the Argyll Array, not particularly deep but the ground conditions are challenging in a harsh offshore environment. In the case of SSE there are internal business decisions but they are not helped by some of the policy landscape that's affecting offshore wind at the moment. So there are a variety of different things, cost, technical, policy issues"*.

It is evident that the regulatory and legislative environment is variable across different Member States of the EU. The National legislative frameworks reflect the EU Directives which apply to offshore wind, wave and tidal energy, but often there is variation between how countries administer such legislative requirements and many associated policies are at different stages of development in different countries. There exist three principal factors that determine the developmental progress of the regulatory/legislative frameworks in each Member State. These include Strategic Environmental Assessments (SEA), Marine Spatial Planning (MSP), and a "one-stop-shop" for planning or consenting. Some countries (such as Scotland and Ireland) are either fully developed or at an advanced stage of implementing frameworks by putting an MSP in place, implementing a "one stop shop" for marine consenting, and putting SEAs in place for each of the offshore wind, wave and tidal sectors. These are important factors for facilitating the development of the offshore renewable energy sector, and other countries, especially France, Norway, Portugal and Spain need to continue to progress in this regard to realise the large opportunities presented by the sector. Table 1 outlines the relative progress each of the Atlantic Area countries have reached in each of the principal factor areas.

Table 1: Development of the regulatory/legislative frameworks in the Atlantic Area

	SEA in place Wind Wave Tidal	MSP in place	"One-stop-shop" in consenting
Scotland	✓✓✓	✓	✓
Ireland	✓✓✓	X	✓
Spain	✓X X	X	X
Portugal	Partial X X	Under Development	X

Source: Authors

6. Strategic Framework

In 2007 EU leaders were able to conclude an agreement to establish a common European Energy Policy that underpins the European vision for energy to the year 2020. The agreement is based on three key principles of sustainability, security of supply and competitiveness. Based on the agreed EU Renewable Energy Directive (RED) issued in 2009 a target of 20% renewable energy consumption was set. The UK has been set a target of 15% for renewable energy consumption by 2020. The RED also requires each Member State to develop a National Account Plan which includes a series of actions to be undertaken to facilitate growth in the sector through carefully designed administration procedures, regulations and codes; information and training; and access to the electricity grid and sustainability.

In Scotland much of the energy policy is set by the Scottish Government but within the overall UK framework legislation set by the UK government. For example, there is close collaboration between the two government bodies via the Department for Energy and Climate Change (DECC). The UK Renewable Energy Strategy (RES) sets out the overall UK Plan on how it will achieve the EU target of 15% renewable energy by 2020. It contains a wide range of actions to facilitate, incentivise and support the increased use of renewables by Government, businesses, communities and individuals. Specific measures have been identified to encourage investment, remove barriers and bring forward the deployment of less well established technologies and currently more expensive, such as offshore wind and marine renewables. Andrew Macdonald of industry support group ORE Catapult highlights the political environment as a key driver of growth - *"Energy is hugely political and has been historically whether it is coal, nuclear or gas. No energy technology has been implemented without political support. In Scotland there is a strong commitment to renewables but also to the oil and gas sector. With all energy sources it comes down to security of supply, economic development, sustainability and cost"*.

The UK RES acknowledges that the Scottish Government are developing their own specific approaches to meet the particular circumstances in Scotland. Europe's offshore wind potential is enormous and able to meet Europe's demand seven times over, as estimated by the European Environment Agency's (EEA). The European Commission anticipated, in its 2008 Communication on offshore wind energy (EC, 2008) that *"offshore wind can and must make a substantial contribution to meeting the EU's energy policy objectives through a very significant increase - in the order of 30-40 times by 2020 and 100 times by 2030 - in installed capacity compared to today."*

7. Innovation

To determine levels of engagement with key aspects of innovation across the green maritime energy industry in Scotland, a survey questionnaire was designed and disseminated to companies across the supply chain. Of the 36 Scottish companies who responded to the questionnaire survey 13 said that they had not engaged in innovation in 2012. This response was broadly similar to those of Ireland and Portugal with only Spain registering a significantly high negative response rate of just over 95%. Just under half of the 34 Scottish companies who responded to the question relating to internal or external marketing activities aimed at the introduction the enterprise's innovation reacted positively. This is a significantly higher number than other Atlantic Area countries in the survey.

A similar trend is evident for the question relating to internal or external training for personnel directly related to innovation activity with 44.4% of Scottish companies reacting positively compared to only 10% for Spain, 7% for Ireland and 16% for Portugal. For innovations aimed at new product or service developments, 22 from 36 Scottish companies reacted positively and were in line with figures from Spain. Most of the innovation that takes place in the Scottish companies surveyed derives from internal rather than external services or research and development (R&D). Only 6 Scottish companies from a total of 36 said they acquired external R&D. There was little evidence of externally acquired R&D in the other surveyed Atlantic Areas countries. However, there was a marked difference in the acquisition of machinery and equipment in connection to product or process innovation with around half the 36 Scottish companies registering a positive response compared to Portugal and Spain where the figure was at around 20%. The acquisition of external knowledge registered a 70% negative response rate in Scotland with similar trends in the other Atlantic Area countries surveyed. Finally, for all design functions around half of Scottish companies surveyed registered a positive response. This is significantly higher than the other Atlantic Area countries surveyed where the average response rate was over 90% negative.

There were 24 Scottish companies that responded to the questions relating to the impact(s) that innovation activities have had on the enterprise in the period 2011-2012. Around two thirds (16 from 24 Scottish respondents) said that the impact of innovation increased the range of goods or services. This is significantly higher than other countries surveyed but the low response rate makes analysis and interpretation difficult. Improvement in the quality of goods and services showed a similar outcome as did the responses to whether or not innovation improved production flexibility. More than half of Scottish companies did not see a reduction in unit labour costs through innovation activity with only 14 from 24 responding negatively - similar figure was registered for the question relating to increasing capacity through innovation activity (14 from 24 responded negatively), improvement in environmental impact or health and safety aspects (11 from 23 responded negatively) and meeting regulations and standards (14 from 24 responded negatively).

There were 26 responses from Scottish companies indicating if their enterprise cooperated with a range of innovation activities with selected other innovation driver organisational types in the period 2011-2012. The results are outlined in Table 2. Clearly, the overwhelming majority of Scottish firms who responded to the survey highlighted cooperation with the selected types of organisations or clients and customers that help drive innovation.

Table 2: Development of the regulatory/legislative frameworks in the Atlantic Area

	Yes	No
Other enterprises within your enterprise group	4	22
Suppliers of equipment, materials, components or software	6	20
Clients or customers	6	20
Competitors	2	23
Consultants	7	18
Commercial laboratories/ R&D enterprises	1	24
Universities or higher educational institutes	6	19
Government research institutions	3	22
Private research institutes	1	24

Source: Authors

8. Human Capital

The human capital report as part of the Harvest Atlantic project reveals some insights into qualifications of personnel, types of qualifications required and where, if any, skills shortages have been identified. Here, the questionnaire survey was extended to incorporate four Atlantic Area countries - Scotland, Portugal, Spain and Ireland, for comparative purposes. In response to the question of qualifications that third level institutions could meet Spain was the only country where organisations responded that they had more staff shortages that third level institutions could meet than not. From 42 respondents, 52.2% of Spanish organisations responded positively to this question even though, relatively, they registered the most Masters and PhD's among the four countries. Scotland and Portugal registered similar responses with around one quarter responding positively with three quarters responding that they did not have qualification shortages that third level institutions could fill. The gap was closer for Ireland with around a sixty/forty percentage split in favour of those who did not have qualification shortages that third level institutions could fill. Significantly, Spain (although registering the most PhD's and Masters) had a relatively low number of staff with degrees and Certificate/Diploma qualifications. This may point to a shortage of qualifications at the Certificate/Diploma and degree level rather than at the highest level of awards. Scotland registered the least percentage for qualifications shortages with only twenty five percent. Only nine from thirty six respondents in Scotland noted a qualifications shortage that third level institutions could fill.

The most significant outcome of the responses to the question of what qualifications organisations would hire was the small number receiving a positive response across all qualification types and across all countries. All organisations across all countries registered negative responses to this question. Where there were positive responses, such as in the case of Spain for the MSc qualification, the total number of organisations responding was too low to make any significant inference. Organisations from each country reported some skills shortages with around one third in Ireland and Spain registering a positive response to the question. Scotland had a significantly lower number of organisations reporting skills shortages while the number of respondents for Portugal was too low to offer any real insight. There were no reported skills shortages in areas of finance and administration, sales and marketing, operations management or product/service innovation. The results from Scotland were too low to give a correct reading of the situation as it is known that the green maritime economy suffers from skills shortages due to the demand for key personnel in the more highly developed oil and gas industry.

9. Market Situation

EWEA (2013) reveals that in 2012, installed wind power capacity in the European Union totalled 105,000 megawatts (MW) - enough to supply 7% of the EU's electricity. 11,895 MW of wind power was installed in 2012 alone, representing 11.4% of new power capacity. The EU wind industry has had an average annual growth of 15.6% over the last 17 years (1995-2011). A European Environment Agency report, entitled *'Europe's onshore and offshore wind energy potential'* confirms wind energy could power Europe many times over. The report highlights wind power's potential in 2020 as three times greater than Europe's expected electricity demand, rising to a factor of seven by 2030. The EWEA estimates that 230 gigawatts (GW) of wind capacity will be installed in Europe by 2020, consisting of 190 GW onshore and 40 GW offshore. This would produce 14-17% of the EU's electricity, avoiding 333 million tonnes of

CO2 per year and saving Europe €28 billion a year in avoided fuel costs.

Scotland's first offshore wind turbine was placed near the Beatrice Oil Field, 15 miles off the east coast in the Moray Firth, North Sea, in August 2006. This was the world's largest wind turbine at the time, an REpower 5M, with a maximum output of 5MW. A second identical turbine joined it and the wind farm began supplying electricity in August 2007 As of February 2010, Beatrice Wind Farm is the deepest and northernmost offshore wind installation in the world. This was the first time such large offshore wind turbines had been tested, and the first time any wind turbine generators have been assembled in such deep (44 metres) water. Such large wind turbine generators are ideally suited to the offshore environment due to high consistent wind speeds and minimal turbulence. According to historical measures of wind speeds at the Beatrice offshore location, it is expected that the turbines will run 96% of the time (8440 hours per year), and at 10 MW full power 38% of the time (3300 hours per year).

10. Policy Implications

There are numerous factors that have linkages to policymaking in the green maritime energy sector. Some have already gained a high profile and public debate, such as the location of offshore windfarms (the highly publicised withdrawal of a proposed golf course and leisure complex to be built by entrepreneur Donal Trump was partly due to the siting of an offshore windfarm within sight of the complex). Three key factors that have policy implications include:

- cost reduction
- global collaboration and knowledge sharing; and
- public support

One of the most important issues linking to policy in the Scottish green maritime energy sector relates to cost. The industry remains in a delicate position as it transverses from experimental to developmental through implementation phases. Meeting the challenges of reducing costs to make the sector viable in the short and long term is a vital element in framing legislation and policy. There has been some significant progress in this regard with installed capacity in the Pentland Firth showing potential for cost reductions to up to 30%. However, in other areas the cost factor has been instrumental in scaling back ambition. For example, the proposed Tiree Array in the Atlantic area was cancelled due to a combination of cost and technical difficulties. Policymakers face a challenge of delivering frameworks that help overcome the cost hurdle. This needs to extent towards parts of the supply chain where costs can easily escalate. For example, technology developers require a clear costing model based on plans to reduce cost. Policymakers need to deliver incentives and support for innovators so that the solutions to some of the technical problems facing the industry can be solved quicker and new and innovative designs created. Improving the technological acceleration in the industry is another cost reducing component, but it also helps to deliver solutions more effectively through the integration of partners along the supply chain. Essentially, policymakers need to design the frameworks that allow 'game-changing' solutions to flourish and open up the market in meaningful way.

One way of achieving this is to further expand global collaboration. Cost sharing is an important driver of expansion of the sector along with knowledge sharing and skills sharing. Drawing on overseas expertise is a necessary component of a developing industry where efforts to reduce cost and risk are key. For policymakers it is a key challenge to speed up the processes that allow collaboration on a global scale. For example, it is evident that the nature of funding that currently exists does not encourage collaboration meaning that some technologies have been developed without access to knowledge or expertise gained from experience of developing devices at a later stage. Effort to codify best practices is an important step towards addressing this weakness with Orkney based testers EMEC at the forefront of developing guidelines. Policymakers can help by ensuring that future funding is linked to knowledge sharing as a best practice. This will help to avoid costly duplication of effort and speed up the developmental stage. The ORE Catapult's Innovation Programmes Director Chris Hill pinpoints the important factors that will determine the future prospects of the industry- *"To improve performance and reduce the costs associated with offshore wind farms, there needs to be greater collaboration amongst industry players to share best practice and learning. If we are going to capitalise on the economic opportunity presented by a strong offshore supply chain, then we need to develop a collective view on what the key technology challenges are, and where the industry should be focusing its combined efforts on developing innovative solutions to drive cost reductions."*

Finally, policymakers need to be better at helping to gain support of stakeholders, and in particular citizens. The argument for an expanded green maritime energy sector has yet to convince many stakeholder groups such as fisheries and environment interests. If public support is to be won over then more robust and evidence-based arguments need to be presented that influence opinion towards support for the industry.

11. Conclusions

This report has mainly presented developments in the green maritime energy sector in Scotland. The discussion has featured policymaking frameworks, support mechanisms, supply chain dynamics, and the regulatory and strategic frameworks at EU and national level. The performance outcomes within this environment are addressed by a market situation analysis of Scotland within an EU context. The situation in Scotland covers three policy levels, namely, the EU directives, UK government policy, and the Scottish government policy. Whilst much of the policymaking is integrated there are some distinct features of the support mechanisms and funding arrangements that pertain to Scotland that this report has highlighted. In other areas there is a UK wide legislative framework for the sector. For example, the remit of the Crown Office to manage the sea bed and derive revenue from the exploitation of it pertains to all sectors of the UK. Similarly, the EU directives relating to factors such as environmental impact are implemented by the UK national government across all regions of the UK.

Many of the policymaking and legislative measures have been designed to support the development of the green maritime energy sector by formalising funding mechanisms, investment pathways, educational and training support facilities, links with institutes and universities, technology development and industry support bodies. Much of the activity has been around finding new and innovative ways of reducing cost and creating technologies that help to expand the capacities of the sector.

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